International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12

Software adaptive model analysis of steel Bridge

Dogga.Sai Mounika[1], Dr. Dumpa Venkateswarlu[2]

[1] M.Tech (student) in structural Engineering, Department of Civil Engineering, Godavari Institute of Engineering and Technology (Autonomous), Rajahmundry, Velugubanda Village, Rajanagaram (Mandal) East Godavari, A.P, India, pin code: 533296.

[2] Professor and Head of the Department, Department of Civil Engineering, Godavari Institute of Engineering and Technology (Autonomous), Rajahmundry, Velugubanda Village, Rajanagaram(Mandal) East Godavari, A.P, India, pin code:533296.

Abstract

Urbanisation requires the need for rapid improvement in the transportation facilities to transport commodities, livestock and goods at faster pace. In order to accommodate this there is an imperative requirement to have short routes connecting the inaccessible areas through obstacles like valleys, rivers etc., and bridging gaps between them by adopting effective methods and by constructing efficient structures to minimize cost, weight, construction time , labour and to maximize the efficiency of the structure. Among all the bridges, steel bridges play a major role in providing enough strength and rigidity satisfying the deflection limits. Hence in order to achieve this, it is necessary to carry out an accurate analysis to investigate the reactions and stresses in the elements of the bridge. This project looks into the concepts and procedure of the parametric investigations and designs of the steel trusses using software's available as they give more reliable results and can provide variable ways of analysis simultaneously.

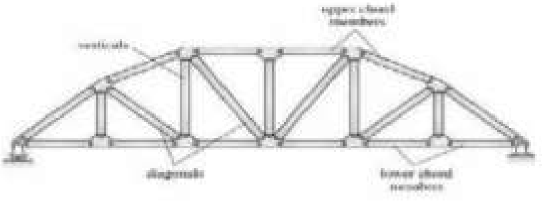
Keywords: ANSYS ,steel bridge, steel struss, efficient structures ,etc,

1. Introduction

TRUSS

A truss is a structure that acts like a beam but with major components, or members, subjected primarily to axial stresses. The members are arranged in triangular patterns. Ideally, the end of each member at a joint is free to rotate independently of the other members at the joint. If this does not occur, secondary stresses are induced in the members. Also if loads occur other than at panel points, or joints, bending stresses are produced in the members.

Though trusses were used by the ancient Romans, the modern truss concept seems to have been originated by Andrea Palladio, a sixteenth century Italian architect. From his time to the present, truss bridges have taken many forms. Early trusses might be considered variations of an arch. They applied horizontal thrusts at the abutments, as well as vertical reactions, In 1820,Ithiel Town patented a truss that can be considered the forerunner of the modern truss. Under vertical loading, the Town truss exerted only vertical forces at the abutments. But unlike modern trusses, the diagonals, or web systems, were of wood lattice construction and chords were composed of two or more timber planks.

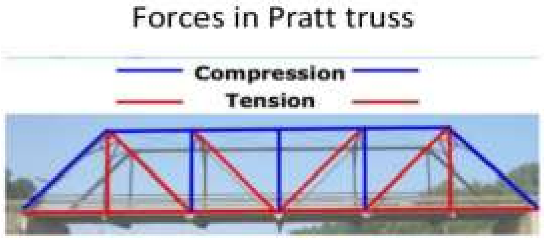


components in trusses

Joints are intersections of truss members. Joints along upper and lower chords often are referred to as panel points. To minimize bending stresses in truss members, live loads generally are transmitted through floor framing to the panel points of either chord in older, shorter-span trusses. Bending stresses in members due to their own weight was often ignored in the past. In modern trusses, bending due to the weight of the members should be considered. Chords are top and bottom members that act like the flanges of a beam. They resist the tensile and compressive forces induced by bending. In a constant-depth truss, chords are essentially parallel.

Types of trusses

Pratt trusses have diagonals sloping downward toward the centre and parallel chords. Warren trusses, with parallel chords and alternating diagonals, are generally, but not always, constructed with verticals to reduce panel size. When rigid joints are used, such trusses are favoured because they provide an efficient web system. Most modern bridges are of some type of Warren configuration.



F

Figure 1: pratt truss

Parker trusses resemble Pratt trusses but have variable depth. As in other types of trusses, the chords provide a couple that resists bending moment. With long spans, economy is improved by creating the required couple with less force by spacing the chords farther apart. The Parker truss, when simply supported, is designed to have its greatest depth at midspan, where moment is a maximum. In practice, therefore, the top chord profile should be set for the greatest change in truss depth commensurate with reasonable diagonal slopes; for example, between 40 and 60 with the horizontal.

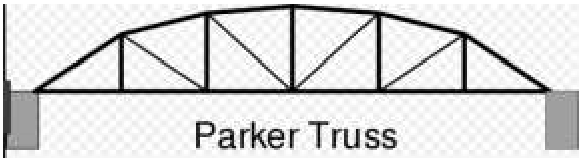


Figure 1:parker truss

K trusses permit deep trusses with short panels to have diagonals with acceptable slopes.Two diagonals generally are placed in each panel to intersect at mid height of a vertical. Thus, for each diagonal, the slope is half as large as it would be if a single diagonal were used in the panel. Thus, K trusses may be economical for long spans, for which deep trusses and narrow panels are desirable. Bridges also are classified as highway or railroad, depending on the type of loading the bridge is to carry.

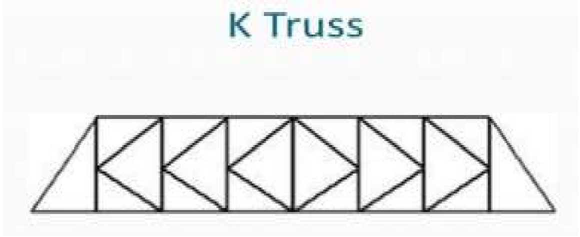


Figure 3: k Truss

Advantages:

There are many advantages of having such a design, and a few are given below:

1. First and foremost the design has an interior railing which is connected to the diagonal span which prevents people from falling down from the edge of a bridge.
2. The truss utilizes Newton's laws of motion especially statics that forms an important part of the laws. The straight components meet at pin joints and the components of the truss will be involved in tension or compression.
3. A bridge built using this design is very strong due to the use of triangles.

Disadvantages:

There are also some disadvantages of a structure like this:

1. Bridges with this type of structure are old and outdated now. Engineers are looking at ways to add to the structures in order to increase their safety.
2. If not designed in the correct manner it can cause a lot of wastage in terms of material because there can be members in the design that do not contribute in any way to the overall structure.

loading on a truss bridge :

Primary loads on railway bridges

- Dead loads.
- Live loads.
- Impact loads (dynamic effect).
- Centrifugal forces.

Secondary loads on railway bridges

- Wind pressure or earthquake.
- Braking forces
- Lateral shock effect.
- Temperature effect.
- Frictional resistance at movable bearing.
- Forces due to settlement of supports.
- Forces due to erection

Finite element analysis:

Engineers in every industry are integrating finite element analysis (FEA) into the design cycle to ensure that their products are safe, cost-effective, and fast to market. But, analysis is not as simple as putting a CAD model into any FEA package. There are more software options today than ever before.

FEA Basics. A finite element model is a discrete representation of the continuous, physical part being analyzed. This representation is created using nodes, which are connected together to form elements. The nodes are the discrete points on the physical part where the analysis will predict the response of the part due to applied loading. When adjacent elements share nodes, the displacement field is continuous across the shared element boundary and loads can be transferred between the elements.

Design Criteria. In any analysis, an engineer first needs to determine the significant physical phenomena and environmental conditions to which the part will be exposed, and also the desired design objective.

The first step in an analysis is to determine whether the design will be subject to static or dynamic conditions. In its real-world application, is the part fixed in space, subject to vibration, or does it move relative to other parts in the assembly?

Multiphysics. In addition to considering a part's ability to withstand mechnical stresses, FEA software often enables engineers to predict other real -world stresses, such as: the effects of extreme temperatures or temperature change (heat transfer analysis), the flow of fluids through and around objects .

Often these effects work in unison, so it is important that the FEA program can consider their effects on one another. For instance, a computer chip may be heating up over time, cooled down by airflow from a fan, vibrated against other parts, and electrically charged.

Motion Simulation. In the past, the design process demanded specialists who could build models for different uses: design, machining, or analysis.

There are three common methods:

- Motion Load Transfer requires engineers to use two applications: a kinematics package is used obtain approximate loads, which are then input to an FEA program for analysis.
- This approach does not simulate the motion of a finite element model, just many approximate static points. It's faster than calculating stresses by hand, but it uses a rigid-body motion program, so the engineer must accept certain assumptions.
- For instance, parts like gaskets are flexible, but a rigid-body program can't calculate that.

Modelling. After determining the type of analysis required and the characteristics of the operating environment, the engineer must produce a finite element model with appropriate analysis parameters, such as loads, constraints, and a suitable mesh. The three available methods of CAD/FEA interoperability can vary widely in terms of ease-of-use, accuracy, and functionality:

The CAD universal file format method requires an engineer to export the CAD solid model to a neutral file format, such as IGES, ACIS or Para solid, and then import the neutral file into the FEA system for setup and analysis. Although this method usually enables engineers to take full advantage of an FEA program, it can also result in the loss of CAD geometry data as the model is translated. .

- The "one window" CAD/FEA method requires no file translation, since the FEA vendor builds analysis capabilities into a CAD solid modeller. Users choose this option for its ease-of-use, as they can access FEA capabilities from a pull-down menu in a single application. However, FEA providers often simplify their one-window versions due to space and interface limitations. In addition, it can also be limited since FEA companies must tailor their product to each CAD vendor's software in order to integrate the two products.
- The "one window away" CAD/FEA method also requires no file translation, but it has the additional abilities to perform FEA analysis on a different computer from the CAD solid modeller, and to use a single interface for multiple CAD packages..

Results Interpretation.

So FEA software must provide result verification or validation tools. Ideally, these tools would not only include displacement, stress, or other result contours, but also precision contours that provide qualitative and quantitative verification.Often, the analysis and modelling choices that an engineer makes will determine how easy it is to interpret results.

objectives of study:

- Effectively analyzing the steel truss bridge for different loadings.
- Obtaining strength parameters for various loads.
- Carrying out simulation.

- Optimizing the critical load carrying elements.

2 Literature review

GA based Optimal Design of Steel Truss Bridge by Pandia Raj and Kalyanaraman stated that the economy of the steel truss girder bridge superstructure, used extensively in medium and long span ranges, is affected by many factors such as the cost of material, dictated by the configuration and depth of truss, shape and size of members, and cost of abrication. Most conventional methods of optimization deal with only member optimization assuming only continuous design variables, leading to designs mathematically feasible, but not necessarily practical.

objective of the paper is to demonstrate the efficient integration of GA for optimization with software in object-oriented environment to design large scale truss bridge superstructure for railway loadings.

Failure Characteristics and Ultimate Load-Carrying Capacity of RedundantComposite Steel Girder Bridges by Amir Gheitasi and Devin Harri

This paper presents an approach for capturing the full system-based behaviour and stages of failure in the composite bridge superstructures as they approach ultimate capacity. This step is instrumental to understanding how redundant bridges behave in the presence of coupled and uncoupled damage and deteriorations. The investigation included a comprehensive nonlinear finite-element analysis of two representative intact composite steel girder bridges that were tested to failure and provided sufficient details for model validation. Results demonstrate the high degree of additional reserve capacity, inherent to redundant superstructures, over the theoretical nominal design capacity. Bridge superstructures play a key role in the national transportation network and recent bridge failures highlight the need to understand the actual response of in-servicebridges and estimate their remaining service life under the effect of different deterioration conditions. In comprehensive experimental programs (Kathol et al. 1995; Burdette and Good pasture 1971), these bridges previously were tested to failure with detailed information collected on the testing procedures and data acquisitions.

3.Design Methodology

Basic steps in design of steel bridge:

- The optimum value for span to depth ratio depends on the magnitude of the live load that has to be carried.
- The span to depth ratio of a truss girder bridge producing the greatest economy of material is that which makes the weight of chord members nearly equal to the weight of web members of truss. Design of compression chord members
- Generally, the effective length for the buckling of compression chord member in the plane of truss is not same as that for buckling out-of-plane of the truss i.e. the member is weak in one plane compared to the other. The ideal compression chord will be one that has a section with radii of gyration such that the slenderness value is same in both planes.

Design of tension chord members

Tension members should be as compact as possible, but depths have to large enough to provide adequate space for bolts at the gusset positions and easily attach cross beam. The width out-of-plane of the truss should be the same as that of the verticals and diagonals so that simple lapping gussets can be provided without the need for packing It should be possible to achieve a net section about 85% of the gross section by careful arrangement of the bolts in the splices.

Design of vertical and diagonal members.

Diagonal and vertical members are often rolled sections, particularly for the lightly loaded members, but packing may be required for making up the rolling margins. This fact can make welded members more economical, particularly on the longer trusses where the packing operation might add significantly to the erection cost.

Theoretical design:

Design of a through type truss girder bridge to carry a single track B.G. (revised) loading,

1. Effective span : 39m
2. Center to center spacing of stringer : 1.9m
3. Sleepers and their spacing's: 250mmX150mmX2.8m @0.4m c/c
4. Density of timber: 7.4kN/m

5. Weight of stock rails: 0.44kN/m (90 lb/yard rails)
6. Weight of guard rails: 0.26kN/m
7. Weight of fastenings etc. : 0.28kN/m of track

figure 5 Theoretical design:

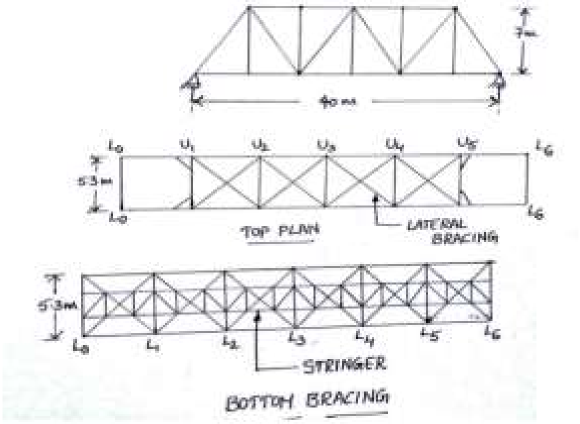
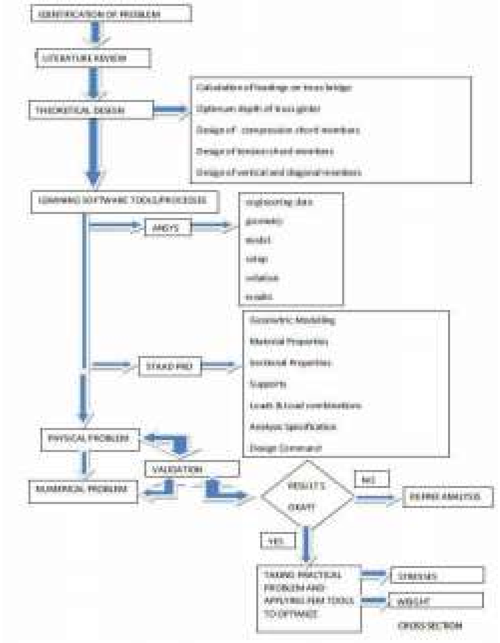


figure 6 flow chart of the project overview:



4 .Softwares

softwares used

ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite element analysis is a numerical method of deconstructing a complex system into very small pieces called element. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. **Functions** Bidirectional, parametric links with all major CAD systems

- Integrated, analysis-focused geometry modelling, repair, and simplification via ANSYS Design Modeller
- Highly-automated, physics-aware meshing
- Comprehensive multi physics simulation

STAAD. Pro

STAAD.Pro is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. The commercial version STAAD.Pro is one of the most widely used structural analysis and design software.

Figure 7 staad model

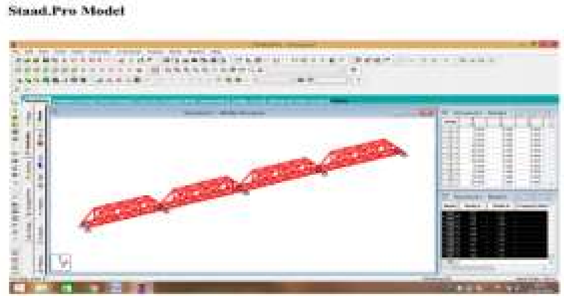


Figure 8 Ansys model

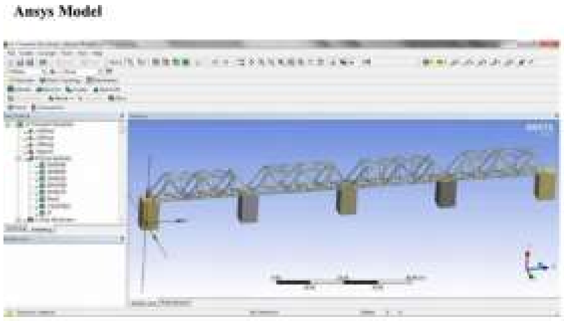
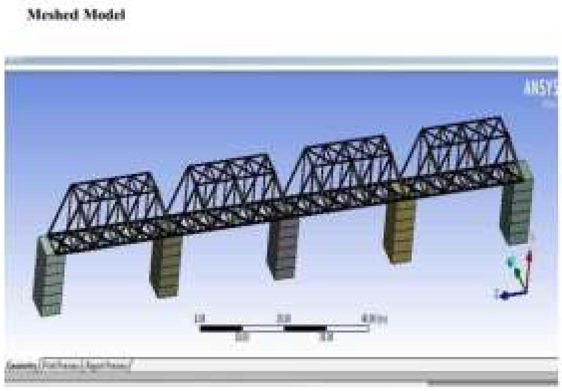
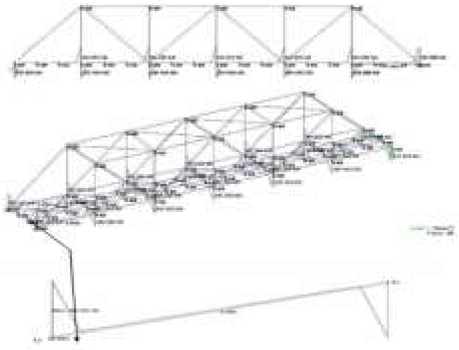


Figure 9 meshed model



5.validation

Figure 10 Theoritical design validation by using software



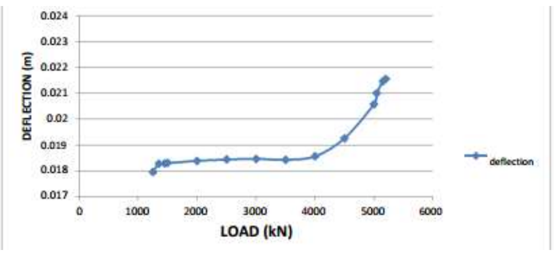
Member	Impact Factor	Area Of Influence Line	Dead Load (kN/m)	Live Load (kN/m)	Force Due To Dl (kN)	Force Due To Ll (kN)	Force Due To Impact (kN)	Total Force
Lol₁ & L₁l₂	0.328	+15.093	9.0	39.91	+135.8	+602.4	+197.6	+935.8

- +935.8kN value is from design.
- By using software max is +947.9 kN

In the similar manner the total forces at other critical points are also verified and compared with the ansys results and are found to be satisfactory.

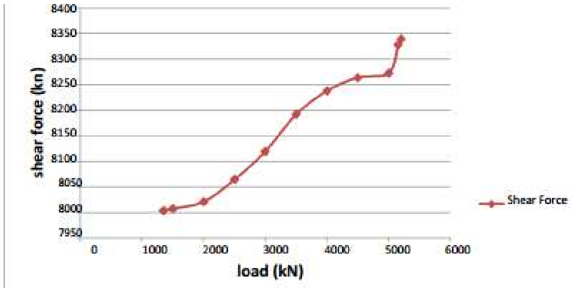
6.Software results and discussions

Deflection results



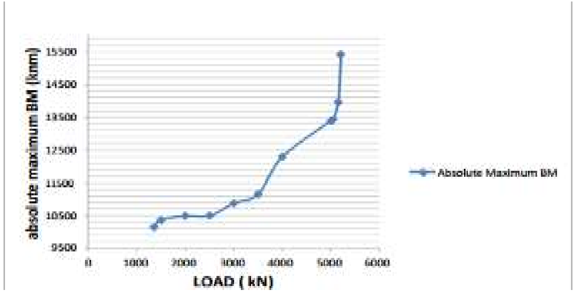
Graph 1 Load Vs Deflection

shear results:



Graph 2 Load Vs Shear Force

Absolute maximum bending moment results:



Graph .3 Load Vs Absolute Maximum BM

Images showing Deflection and Shear Force after analysis

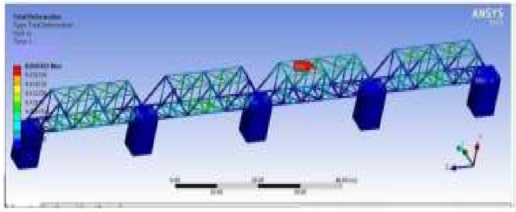


Figure 11

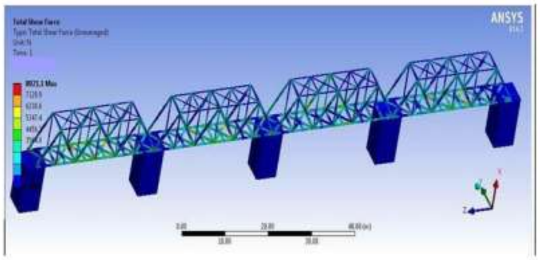


Figure 12

Images showing Bending Moment and Combined stress

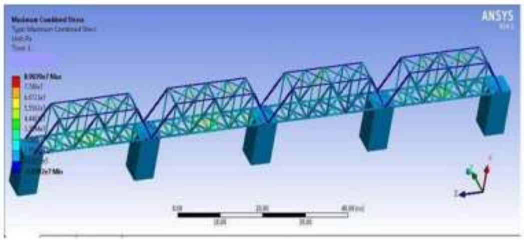


Figure 13

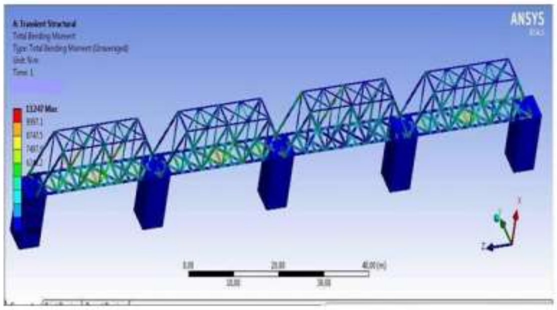


Figure 14

Failure point

Existing structure had failed at 5300 kN

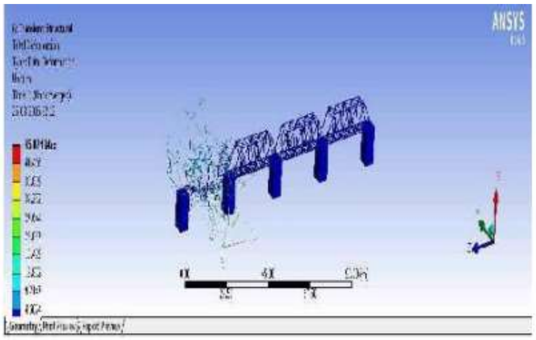
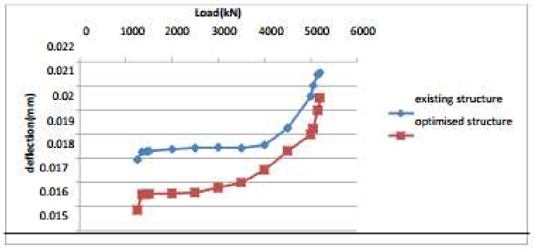


Figure 15

optimization results



Graph 4 Load Vs Deflection

After Optimization Image showing Deflection For 4500kN

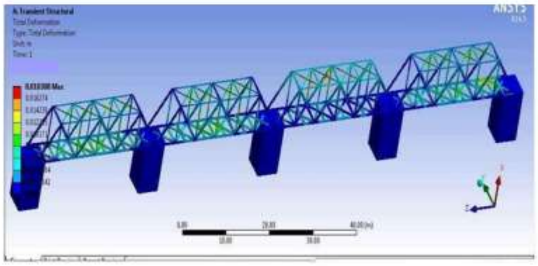


Figure 16

Image Showing Deflection at 1250kN

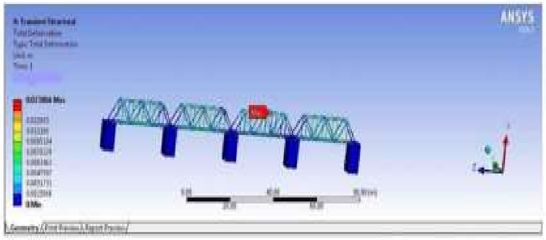
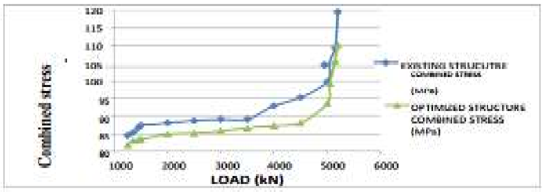


Figure 17

change in combined stress by change in cross section



Graph 5 Load Vs Combined Stress

Image Showing Combined stress at 3500kN

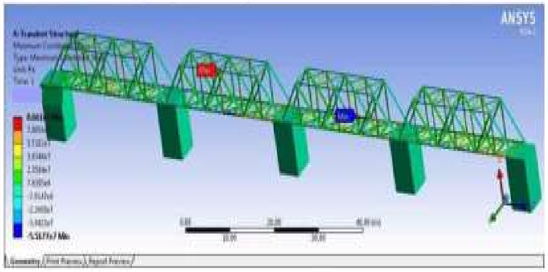


Figure 18

Image Showing Combined stress at 4500kN

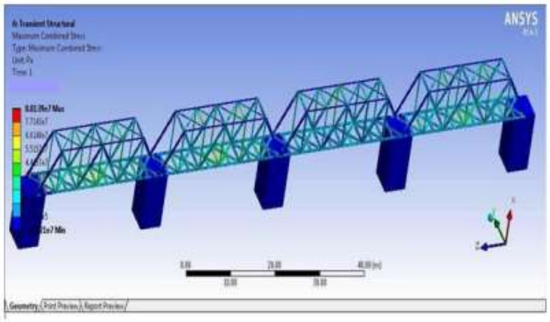
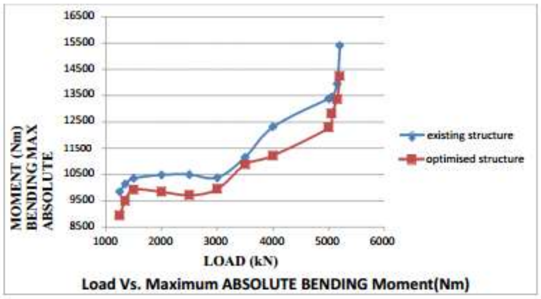


Figure 19

change in crosssection



Graph 6. Load Vs Max Absolute BM

After Optimization Image Showing Bending Moment for 3500 kN load

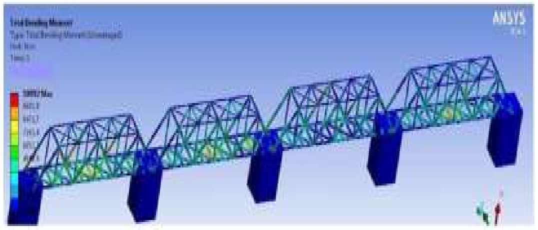


Figure 20

change in weight of steel

Graph 7 Load Vs Steel Takeoff

Results and discussions

Simulations and Analysis had been carried out using Staad pro and Ansys for the existing structure from minimum (1250kN) to maximum loads until the structure failed i.e, (5300kN).

- After Analysis important parameters like bending moment, shear forces, combined stresses, deflections have been obtained.
- Modifications to the Existing structure to accommodate the future traffic load which
- are likely due to increase in traffic and speed requirements.
- Out of various feasible options available, option of improving the cross section at the critical points is considered in this study and simulations were carried out.
- The above simulations resulted in the following results for the load carrying capacity of the existing elements.
- Absolute Bending moment for the Modified Structure has been increased by 7.5% with a small increase in area of 0 .0043m
- Combined Stress for the Modified Structure also has been increased by 8%.
- Average Deflections has been decrease by 9% Compared to existing structure.
- Steel take off had been calculated for existing and Modified structure and comparisons have been tabulated.
- Load carrying capacity of the structural elements has been improved to 5200 kN from 3500 kN (Yield Load).

7.conclusions

- Important strength parameters like absolute maximum bending moment, maximum combined stress and deflections have been effectively improved by 7.5%, 8%, 9% respectively.
- Every one lakh increase in costtheload carrying capacity is increased by 800kN.
- REAL TIME SCALE MODELLING of the existing structures and simulating them o the unforeseen forces, using software's will help us in giving economical solutions meeting future requirements both in aspect of structural strengthening and cost benefit ratio.

References

1.Amir Gheitasi, S.M.ASCE and Devin K. Harris, Ph.D., A.M.ASCE (2011) Failure Characteristics and Ultimate Load-Carrying Capacity of Redundant Composite Steel Girder Bridges: Case Study

2.Dr. Michel Ghosn ,Graziano Fiorillo (205) Non-linear Redundancy Analysis of Truss Bridges.

3. Masato Abé, M.ASCE and Makoto Shimamura (2012) Performance of Railway Bridges during the 2011 Tohoku Earthquake.

4. R. Pandia Raj, V. Kalyanaraman (2013) GA based Optimal Design of Steel Truss Bridge

5.Z. W. Chen, M.ASCE; Y. L. Xu, F.ASCE; Q. Li; and D. J. Wu(2007) Dynamic Stress Analysis of Long Suspension Bridges under Wind, Railway, and Highway Loadings.

6.K. R. Pennings, K. H. Frank, S. L. Wood, etal....(August 2000) Lateral load distribution on transverse floor beams in steel plate girder bridges

7.Y. Q. Ni, X. W. Ye; and J. M. Ko (2010) monitoring-Base Fatigue Reliability Assessment of Steel Bridges: Analytical Model and Application.

8.Theory of structures by S.Ramamrutham

9.Design of Steel structures by B.C.Punmia.

10.EFFICIENT INFRASTRUCTURE, a trade magazine on infrastructure technology.